

## CLAIMS

### IN THE CLAIMS:

Sub A 7  
1610 1. A software-based, flexible computer architecture for communication and cooperation among distributed electronic agents, the architecture contemplating a distributed computing system comprising:

a plurality of service-providing electronic agents;

1615 a distributed facilitator agent functionally distributed across at least two computer processes, the facilitator agent capable of bi-directional communications with the plurality of service-providing electronic agents, the facilitator agent including:

an agent registry that declares capabilities for each of the plurality of service-providing electronic agents currently active within the distributed computing environment; and

1620 a facilitating engine operable to interpret a service request as a base goal, the facilitating engine further operable coordinate a suitable delegation of sub-goal requests to best complete the requested service request.

1625 2. A software-based, flexible computer architecture as recited in claim 1 wherein the distributed facilitator agent includes a plurality of single process facilitator agents each executing within a separate computer process, each of the single process facilitator agents being bi-directionally coupled with at least one other single process facilitator agent.

1630 3. A software-based, flexible computer architecture as recited in claim 2 wherein each single process facilitator agent has

any necessary facilitating functionality, a specific single process facilitator including:

a specific agent registry that declares capabilities for each of the plurality of service-providing electronic agents currently active within the process wherein the specific single process is executing, the specific agent registry further declaring capabilities made available to the specific single process facilitator agent through the at least one other single process facilitator agent bi-directionally coupled with the specific single process facilitator agent; and

a specific facilitating engine operable to interpret a service request as a base goal, the facilitating engine further operable to determine sub goals required to complete the base goal; the facilitator engine further operable to select service providing agents best capable of coupling the sub goal and assigning the sub goals thereto.

4. A software-based, flexible computer architecture as recited in claim 3 wherein at least two of the plurality of single process facilitator agents reside upon separate computer systems.

5. A computer architecture as recited in claim 4, wherein the basis for the computer architect is an Interagent Communication Language (ICL) enabling agents to perform queries of other agents, exchange information with other agents, and set triggers within other agents, the ICL further defined by an ICL syntax supporting compound goal expressions such that goals within a single request provided according to the ICL syntax may be coupled by a conjunctive operator, a disjunctive operator, a conditional execution operator, and a parallel

disjunctive operator that indicates that disjunctive goals are to be performed by different agents.

1665        6. A computer architecture as recited in claim 5, wherein the ICL is computer platform independent.

1670        7. A computer architecture as recited in claim 6 wherein the ICL is independent of computer programming languages in which the plurality of agents are programmed.

1675        8. A computer architecture as recited in claim 7 wherein the ICL syntax supports explicit task completion constraints within goal expressions.

9. A computer architecture as recited in claim 8 wherein possible types of task completion constraints include use of specific agent constraints and response time constraints.

1680        10. A computer architecture as recited in claim 8 wherein the ICL syntax supports explicit task completion advisory suggestions within goal expressions.

1685        11. A computer architecture as recited in claim 5 wherein the ICL syntax supports explicit task completion advisory suggestions within goal expressions.

12. A computer architecture as recited in claim 5 wherein each autonomous service-providing electronic agent defines and publishes a

1690 set of capability declarations or solvables, expressed in ICL, that describes services provided by such electronic agent.

13. A computer architecture as recited in claim 12 wherein an electronic agent's solvables define an interface for the electronic agent.

1695

14. A computer architecture as recited in claim 1 wherein the distributed facilitator agent is formed in a hierarchical topology.

1700

15. A computer architecture as recited in claim 14 wherein the hierarchical topology includes a top level facilitator agent and at least one other facilitator agent registered within the top level facilitator agent, the top level facilitator agent operable to directly manage those service-providing agents registered within the top level facilitator agent and indirectly manage those service-providing agents registered within the at least one other agent registered with the top level facilitator agent.

1705

1710

16. A computer architecture as recited in claim 15 wherein the top level facilitator agent and the at least one other facilitator agent are executing on different computer systems.

1715

17. A computer architecture as recited in claim 15 wherein the at least one other facilitator agent is installed for a specific computer user.

18. A computer architecture as recited in claim 15 wherein the at least one other facilitator agent is installed for a specific group of users.

1720 19. A computer architecture as recited in claim 15 wherein the at least one other facilitator agent is installed for a specific computer application.

1725 20. A computer architecture as recited in claim 1 wherein the distributed facilitator agent includes a planning component executing within a first computer process and an execution component executing within a second computer process.

1730 21. A computer architecture as recited in claim 20 wherein the planning component is one of a plurality of synchronized planning components each executing with separate computer processes, whereby the computer architecture provides a more robust operating environment due to redundancy of the planning component functionality of the distributed facilitator agent.

1740 22. A software-based flexible computer architecture for communication and cooperation among distributed electronic agents, the architecture contemplating a distributed computing system comprising:

a plurality of service providing electronic agents;  
at least one facilitator agent capable of receiving a service requests in the form of a base goal from a client agent in an interagent communication language and capable of determining

1745 sub goals necessary to accomplish the base goal, the facilitator operable to allocate each sub-goal to at least one server agent capable of accomplishing the sub-goal as determined by the registry; and

1750 at least one agent capable of making a request directly to a server agent as a peer to peer communication for accomplishment of at least one of the sub-goals.

1755 23. A software based, flexible computer system as recited in claim 22 wherein the peer to peer communication is in a language other than an interagent communication language.

1760 24. A software based, flexible computer system as recited in claim 22 wherein the peer to peer communication is bi-directional.

25 A software based, flexible computer system as recited in claim 22 wherein the agent operable to make said peer to peer service request is said facilitator agent.

1765 26. A distributed facilitator agent functionally distributed across at least two computer processes, the distributed facilitator agent arranged to coordinate cooperative task completion within a distributed computing environment having a plurality of autonomous service-providing electronic agents, the distributed facilitator agent comprising:

1770 an agent registry that declares capabilities of service-providing electronic agents currently active within the distributed computing environment; and

1775        a facilitating engine operable to parse a service request in order to interpret a compound goal set forth therein, the service request formed according to an Interagent Communication Language (ICL), the facilitating engine further operable to coordinate a suitable delegation of sub-goal requests to complete the requested service.

1780        27. A facilitator agent as recited in claim 26, wherein the facilitating engine is capable of modifying the goal satisfaction plan during execution, the modifying initiated by events such as new agent declarations within the agent registry, decisions made by remote agents, and information provided to the facilitating engine by remote agents.

1785        28. A facilitator agent as recited in claim 26 wherein the agent registry includes a symbolic name, a unique address, data declarations, trigger declarations, task declarations, and process characteristics for each active agent.

1790        29. A facilitator agent as recited in claim 26 wherein the facilitating engine is operable to install a trigger mechanism requesting that a certain action be taken when a certain set of conditions are met.

1795        30. A facilitator agent as recited in claim 29 wherein the trigger mechanism is a communication trigger that monitors communication events and performs the certain action when a certain communication event occurs.

31. A facilitator agent as recited in claim 29 wherein the trigger  
1800 mechanism is a data trigger that monitors a state of a data repository and  
performs the certain action when a certain data state is obtained.

32. A facilitator agent as recited in claim 31 wherein the data  
repository is local to the facilitator agent.  
1805

33. A facilitator agent as recited in claim 26 wherein the data  
repository is remote from the facilitator agent.

34. A facilitator agent as recited in claim 29 wherein the trigger  
1810 mechanism is a task trigger having a set of conditions.

35. A facilitator agent as recited in claim A1, the  
facilitator agent further including a global database accessible to at  
least one of the service-providing electronic agents.  
1815

36. A facilitator agent as recited in claim A1 wherein the  
distributed facilitator agent includes a plurality of single process  
facilitator agents each executing within a separate computer  
process, each of the single process facilitator agents being bi-  
directionally coupled with at least one other single process  
1820 facilitator agent.

37. A facilitator agent as recited in claim 36 wherein each  
single process facilitator agent has any necessary facilitating  
1825 functionality, a specific single process facilitator including:

a specific agent registry that declares capabilities for each of the plurality of service-providing electronic agents currently active within the process wherein the specific single process is executing, the specific agent registry further declaring capabilities made available to the specific single process facilitator agent through the at least one other single process facilitator agent bi-directionally coupled with the specific single process facilitator agent; and

1830 a specific facilitating engine operable to parse a service request in order to interpret an arbitrarily complex goal set forth therein, the facilitating engine further operable to construct a goal satisfaction plan including the coordination of a suitable delegation of sub-goal requests to best complete the requested service.

1840 38. A facilitator agent as recited in claim 37 wherein at least two of the plurality of single process facilitator agents reside upon separate computer systems.

1845 39. A facilitator agent as recited in claim 38 wherein the distributed facilitator agent is formed in a hierarchical topology.

1850 40. A facilitator agent as recited in claim 39 wherein the hierarchical topology includes a top level facilitator agent and at least one other facilitator agent registered within the top level facilitator agent, the top level facilitator agent operable to directly manage those service-providing agents registered within the top level facilitator agent and indirectly manage those service-providing agents registered within the at least one other agent registered with the top level facilitator agent.

1855        41. A facilitator agent as recited in claim 40 wherein the top level facilitator agent and the at least one other facilitator agent are executing on different computer systems.

1860        42. A facilitator agent as recited in claim 40 wherein the at least one other facilitator agent is installed for a specific computer user.

1865        43. A facilitator agent as recited in claim 40 wherein the at least one other facilitator agent is installed for a specific group of users.

1870        44. A facilitator agent as recited in claim 40 wherein the at least one other facilitator agent is installed for a specific computer application.

1875        45. A facilitator agent as recited in claim A1 wherein the distributed facilitator agent includes a planning component executing within a first computer process and an execution component executing within a second computer process.

1880        46. A facilitator agent as recited in claim 45 wherein the planning component is one of a plurality of synchronized planning components each executing with separate computer processes, whereby the computer architecture provides a more robust operating environment due to redundancy of the planning component functionality of the distributed facilitator agent.

47. A facilitator agent for coordinating cooperative task completion within a distributed computing environment having a plurality of autonomous service-providing electronic agents, the distributed facilitator agent comprising

a registry of capabilities of the service providing agents; and  
a facilitating engine operable determine a set of sub goals necessary to accomplish the base goal, and then allocate such sub-goals to those agents capable of accomplishing the base goals as determined by the registry, said facilitator further capable of initiating a direct peer to peer communication of at least one sub-goal.

48. A facilitator as set forth in claim 47 wherein the peer to peer communication is in a language other than an interagent communication language.

49. A facilitator as set forth in claim 47 wherein the facilitator agent is functionally distributed across at least two electronic agents.

50. A facilitator as set forth in claim 49 wherein the peer to peer communication is between said distributed facilitator agents.

51. A computer-implemented method for providing cooperative task completion within a distributed computing environment, the distributed computing environment including a plurality of autonomous electronic agents, the distributed computing environment supporting an Interagent Communication Language, the computer implemented method comprising the acts of:

providing a plurality of synchronized agent registries each  
declaring capabilities of service-providing electronic agents currently  
active within the distributed computing environment, the plurality of  
1915 synchronized agent registries each resident within a separate computer  
process;

interpreting a service request in order to determine a base goal, the  
service request adhering to an Interagent Communication Language  
(ICL), the act of interpreting including the sub-acts of:

1920 determining sub-goals required in completing the base goal,  
selecting service-providing electronic agents from an  
available one of the plurality of agent registries suitable for  
performing the determined sub-goals, and  
1925 ordering a delegation of sub-goal requests to best complete  
the requested service; and  
implementing the base goal satisfaction plan.

52. A computer implemented process as recited in claim 51 wherein  
the step of interpreting a service request is controlled by a computer  
1930 process separate from the computer processes wherein the plurality of  
synchronized agent registries reside.

53. A computer implemented process for providing coordinated task  
completion within a distributed computing environment, the distributed  
1935 computing environment including a plurality of autonomous electronic  
agents, the computer implemented method comprising the steps of:

providing at least one agent registry including capabilities of  
service providing electronic agents;  
interpreting a service request in the form of a base goal, the service  
1940 request being in a interagent communication language;

determining a plurality of sub goals necessary to accomplish the base goal;

selecting from said registry at least one service providing agent capable of completing said sub goals;

1945 delegating at least one sub goal as a peer to peer service request directly from a service requesting agent to a service providing agent; and

delegating any remaining sub goals as service request in the interagent communication language to the selected agents capable of completing the remaining sub-goals.

1950

54. A computer-implemented method for providing cooperative task completion within a distributed computing environment, the distributed computing environment including a plurality of autonomous electronic agents, the distributed computing environment supporting a dynamically expandable Interagent Communication Language ("ICL"), the computer implemented method comprising the acts of:

1955 providing a plurality of synchronized agent registries each declaring a set of functional capabilities for one or more of the autonomous electronic agents, each of the synchronized agent registries being resident within a separate computer process;

1960 receiving a service request adhering to the ICL;

determining one or more sub-goal requests in order to perform the service request;

1965 determining a delegation plan that assigns the sub-goal requests to one or more of the autonomous electronic agents, based upon the capabilities declared in one or more of the agent registries; and

implementing the delegation plan.

55. A computer implemented method as recited in claim 54  
1970 wherein the act of providing a plurality of agent registries further includes replicating at least a portion of one or more of the synchronized agent registries across a plurality of separate computer processes.

56. A computer implemented method as recited in claim 54  
1975 wherein the act of implementing the delegation plan is controlled by a computer process separate from the computer processes wherein the plurality of synchronized agent registries reside.